



Application Note

AN2388

Voice Player with ADPCM Decoder

Author: Ruslan Bachinsky

Associated Project: Yes

Associated Part Family: CY8C24794, CY8C24894

Software Version: PSoC Designer™ 4.3

Associated Application Notes: None

Abstract

This Application Note presents details about a device that plays a voice recording downloaded to the external Flash memory via a USB interface. Adaptive differential pulse-code modulation (ADPCM) is used for sound compression.

Introduction

Voice players are widely used in systems with voice notification (such as modern PC motherboards, control systems, industrial and medical equipment) and children's toys.

This device is simple, inexpensive, requires a minimum number of external components, and can be used in various systems. Voice data is downloaded to the device from a PC via a USB interface. Table 1 contains the main device characteristics.

Table 1. Device Characteristics

Item	Value
Power Supply Voltage	9V – 12V
Communication Interface	USB
Input Audio File Bits/Sample	16
Input Audio File Sample Rate	8 kHz
ADPCM Bits/Sample	4
Maximum Duration of the Sound	2 minutes
Flash Memory Capacity	4 Mbits
Flash Memory Writing Time	40 sec

ADPCM Coding

An adaptive differential pulse-code modulation (ADPCM) algorithm is used for voice signal compression. This algorithm uses predictive techniques to calculate a prediction of what the next sample will be, and then stores the difference between the actual sample value and the predicted value.

If the prediction is accurate, the difference between the predicted value and the actual value is very small, so the space required to store it is also small.

The coder and decoder use the same algorithms, so the signal can be recreated from the series of stored differences.

Most ADPCM algorithms are computationally complex and use floating-point arithmetic. G.721 is one such algorithm. You can read more about G.721 on the [International Telecommunication Union](#) web site. This algorithm cannot be realized on an 8-bit microcontroller due to its complexity. Other techniques are used on microcontrollers.

In this Application Note, a simplified version of an ADPCM algorithm is used. This version converts 16-bit samples to 4-bit codes.

Device Operation

A block diagram of the voice player is shown in Figure 1. The device consists of the following components:

- A PSoC® device
- Flash memory for voice storage
- An amplifier
- A speaker
- A play button

The PSoC device receives ADPCM compressed voice data from the PC via USB and writes the data to external Flash memory. When the **Play** button is pressed, the PSoC device begins decoding the ADPCM compressed data and sends the resulting voice samples to the amplifier.

The PSoC CPU communicates with external Flash memory using the SPI master (SPIM) User Module.

It also reads and writes ADPCM codes, and converts ADPCM codes to voice samples.

The PRS PWM is implemented with the PRS16 User Module, a pseudo-random sequence generator. The PRS PWM obtains the samples and generates pulse sequences with a duty cycle that corresponds to the voice sample value. The PRS16 User Module was chosen because the signal spectrum generated by the PRS PWM is wider than the signal spectrum generated by a counter-based PWM.

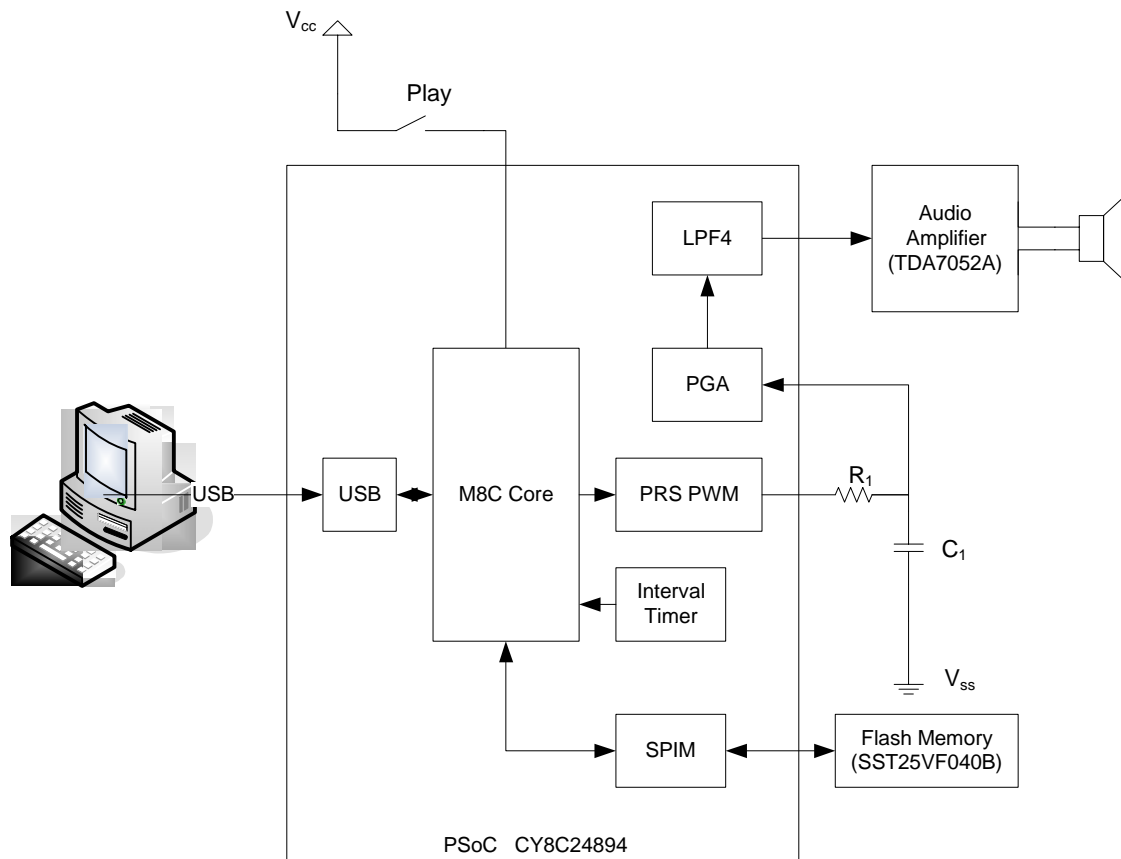
The wider signal spectrum simplifies filtering. The PRS PWM provides a 12-bit resolution output signal that is more than sufficient for this application.

The passive R_1C_1 low pass filter (LPF) removes the high frequency components generated by the PRS PWM.

The filter output signal is routed to a PGA User Module configured as a unity gain buffer. The PGA output is routed to the LPF2 User Module configured as a 4-pole Butterworth LPF (LPF4) with a cut-off frequency of 4 kHz. This suppresses voice sample frequency spectrum components.

The audio amplifier boosts the voice signal for the 8-ohm speaker that plays the voice.

Figure 1. Voice Player Block Diagram

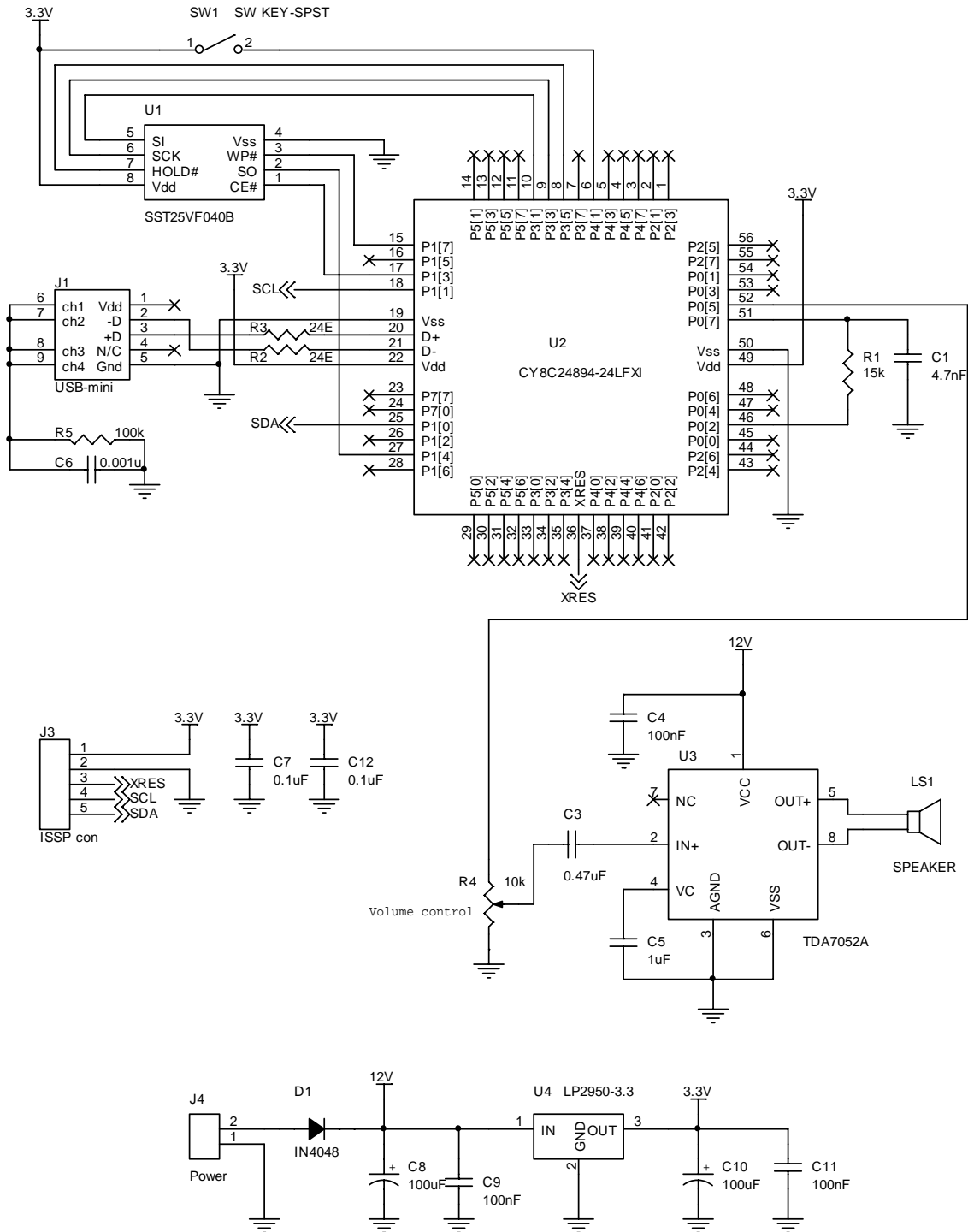


Device Schematic

A schematic of the voice player is shown in Figure 2. Device components and their functions are as follows:

- U1 – External Flash memory
- U2 – PSoC
- U3 – Audio amplifier
- U4 – 3.3V linear voltage regulator
- J3 – ISSP connector for PSoC programming
- R4 – Volume regulator

Figure 2. Voice Player Schematic



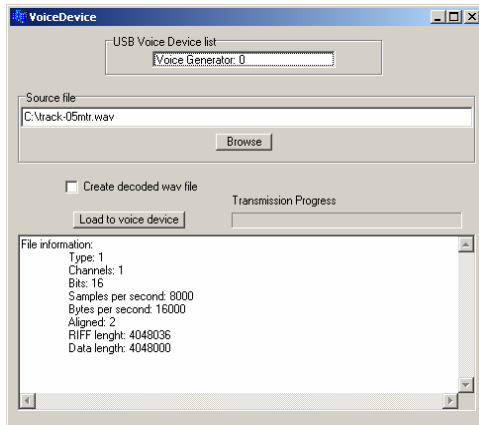
PC Application

The PC communicates with the device through a USB interface. A special PC application converts input WAV files to ADPCM codes and transmits the ADPCM data to the device.

Screen shots of the PC application are shown in Figure 3. The **USB Voice Device list** shows all voice players connected to the PC. Choose any active voice player from the list to interact with that device. Select a .WAV file from the **Source file** field to download the file to the device.

The .WAV file must be a resource interchange file format (RIFF) file that contains a 16-bit sample (1 or 2 channels) with an 8 kHz sample rate. If you want to reconstruct the .WAV file from the resulting ADPCM file, select the **Create decoded wav file** check box. The name of the reconstructed file will be `source_file_name_recovered.wav`. You can listen to this file on the PC without downloading it to the voice player. The ADPCM file name is `source_file_name.adpcm`. This file is transmitted to the voice player via USB.

Figure 3. PC Application View



System Photo

A top view of the PC board is shown in Figure 4. Figure 5 shows a bottom view.

Figure 4. PCB Top View

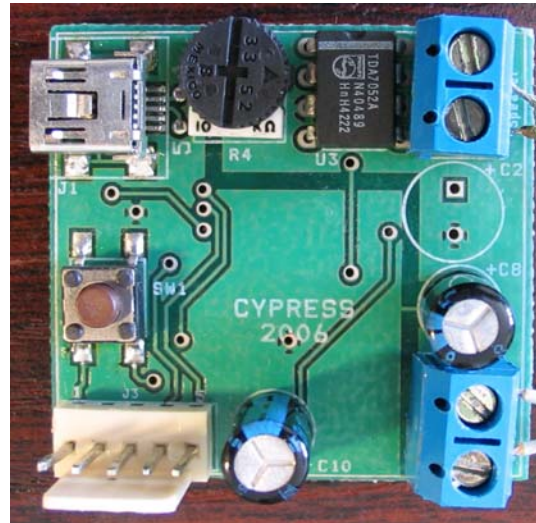


Figure 5. PCB Bottom View



Conclusion

You can use this inexpensive voice player with an ADPCM decoder in voice notification systems by adding a simple command interface that allows you to play different files in response to commands.

About the Author

Name: Ruslan Bachinskyy

Title: Postgraduate Student

Background: Ruslan earned a Master's degree in Specialized Computer Systems in 1999 from National University "Lvivska Polytechnika" (Ukraine), and works as an Application Engineer for Cypress Semiconductor Corp. His interests include embedded systems design including various processors, operating systems, and target applications.

Contact: bac_ruslan@ukr.net

Cypress Semiconductor
198 Champion Court
San Jose, CA 95134-1709
Phone: 408-943-2600
Fax: 408-943-4730
<http://www.cypress.com>

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